# The Role of Thermal Science for Nuclear Disaster Resilience


Kunugi


Sugimoto


Kitamura


Corradini


Hassan


**Moderator**

**Prof. Tomoaki Kunugi**
**Head, Department of Nuclear Engineering, , Kyoto University, Japan**

**Panelists**

**Prof. Jun Sugimoto, Department of Nuclear Engineering, Kyoto University, Japan**
**Emeritus Prof. Masaharu Kitamura, Tohoku University & President, Research Institute for Technology Management Strategy, Japan**
**Prof. Michael Corradini, Nuclear Engineering & Engineering Physics, University of Wisconsin-Madison, U.S.A.**
**Prof. Yassin Hassan, Head, Department of Nuclear Engineering, Texas A&M University, U.S.A.**



**Abstract**

**The Great East Japan Earthquake in March, 2011 triggered the accident at the Fukushima Daiichi nuclear power plant in Japan. Several investigation committees in Japan have issued final reports, which include important lessons learned from the accident. Moreover, a committee established by the National Research Council of the US National Academy of Sciences is also preparing a report to the Nuclear Regulatory Commission and the Congress for improving the safety and security of nuclear plants in the US. Through those activities, the importance and necessity of "resilience in the nuclear engineering" have been emphasized.**

**The IHTC-15 should give us an opportunity to explore what the resilience in the nuclear energy utilization is and how to manage unexpected disastrous situations from a viewpoint of thermal science and engineering. So, this panel is planned to first summarize the existing knowledge and experiences related to the disaster resilience and then to clarify the critical technological issues of nuclear reactor systems. We hope we will reach a coherent view on the resilience engineering among us regardless of nuclear experts or not and will hopefully discuss how to develop human resources serving with this indispensable knowledge in the future.**

**To help and enhance the discussion among the participants, the following presentations will be made by international leaders:**

- **"Resilience Related Lessons Learned from Fukushima Daiichi Accident" (Sugimoto)**
- **"Resilience Engineering and Safety-II for Advanced Accident Management" (Kitamura)**
- **"Resilience in Engineering for Long-Term Cooling in Nuclear Power Plants" (Corradini)**
- **"The role of Computational Fluid Dynamics & Safety System Codes for Nuclear Reactor Predictions and Nuclear Disaster Resilience" (Hassan)**

# Prof. Jun Sugimoto

Department of Nuclear Engineering, Kyoto University, Japan

He received Bachelor of Physics in1973, Master of Engineering in 1975 and PhD of Engineering in 1989 from Kyoto University.

He joined Japan Atomic Energy Agency in 1975. He was Head of Severe Accident Research Laboratory, Director of Vienna Office and Director of Nuclear Human Resource Development Center. He moved to Kyoto University in July 2011.

He served as Vice Chairperson of OECD RASPLAV Program Review Group (1996-1999), Member of IAEA Standing Advisory Group on Technical Assistance and Cooperation (2007, 2010, 2012-2014), and Chairperson of Scientific Advisory Committee of International Science and Technology Center based in Moscow (2008-2011).

He has been involved in the research fields of nuclear reactor safety, especially severe accident research for light water reactors and advanced nuclear energy systems. After Fukushima accident he has been interested in resilience engineering.

He received the Best Paper Award of Atomic Energy Society of Japan in1986.
He received Technical Award of Atomic Energy Society of Japan in 1999.

# Emeritus Prof. Masaharu Kitamura


## Tohoku University
## President, Research Institute for Technology Management Strategy, Japan


He is operating a company named Research Institute for Technology Management Strategy, Ltd., which he founded in 2012. The purpose of the company is to develop and distribute dependable methodology for safety improvement of complex, large-scale socio-technical systems. He is currently active in application targets such as nuclear facilities, air traffic control systems and healthcare systems.

He is entitled Emeritus Professor, Tohoku University, and also serving as Senior Research Fellow of New Industry Creation Hatchery Center, Tohoku University. He obtained B.S, M.S., and Ph.D. from Faculty of Engineering, Tohoku University.

He started his academic carrier as a research associate at Department of Nuclear Engineering, Tohoku University in 1970. Since then, he conducted various joint research projects with Japan Atomic Research Institute, Power Reactor and Nuclear Fuel Development Corporation, Tohoku Electric Power Company, etc. From 1978 to 1980, he worked as post-doctoral research fellow at University of Tennessee and Oak Ridge National Laboratory.
From 1992 to 2005, he served as professor at Department of Nuclear Engineering, Tohoku University.

His research area includes: Nuclear Instrumentation and Control, Intelligent Signal Processing, Human-Machine Systems, Human Factors, Engineering Ethics, and Public Communication on Science and Technology. A few years prior to Fukushima-Daiichi Nuclear Disaster, he has expanded his research area to a new domain of safety study named Resilience Engineering. He believes that the methodology of Resilience Engineering is imperative for significant improvement of nuclear safety in Japan.

# Prof. Michael Corradini

Nuclear Engineering & Engineering Physics, University of Wisconsin-Madison, U.S.A.

He served from 1995 to 2001 as Associate Dean for the College of Engineering and as Chair of Engineering Physics from 2001-2011.

He has published widely in areas in multiphase flow, such as vapor explosions, jet spray dynamics, and containment heat transfer.

In 1998, he was elected to the National Academy of Engineering. He was also served as a presidential appointee in 2002 and 2003 as the chairman of the Nuclear Waste Technical Review Board (a separate government agency).

From 2004-2008, he served as a board member of the INPO National Accreditation Board for Nuclear Training.

In 2006, he was was appointed to the NRC Advisory Committee on Reactor Safeguards and was elected to the National Council on Radiation Protection.

Most recently, he was appointed Chair of the Scientific Advisory Committee to the French Atomic Energy Agency. He began and now serves as the Director of the Wisconsin Energy Institute. He was elected as the President of the American Nuclear Society for 2012 - 2013.

# Prof. Yassin Hassan

## Head of the Department of Nuclear Engineering, Texas A&M University

He is Sallie and Don Davis'61 Professor of Engineering and also Professor of the Department of Mechanical Engineering at Texas A&M University.

Prior to joining Texas A&M September 1986, he worked for seven years at Nuclear Power Division, Babcock & Wilcox Company, Lynchburg, Virginia.

His research interest is in computational and experimental thermal hydraulics, reactor safety, laser-based flow visualization and diagnostic imaging techniques, system modeling, multiphase flow, transient and accident analyses and advanced nuclear reactors.

He received his Ph.D. and MS in nuclear engineering from University of Illinois, and MS in mechanical engineering from University of Virginia.

He is a fellow of American Association for the Advancement of Science (AAAS), a fellow of American Nuclear Society (ANS) and a fellow of American Society of Mechanical Engineers (ASME), and awarded 2008 American Nuclear Society Seaborg Medal, 2003 George Westinghouse Gold Medal award and 2004 Thermal Hydraulics Technical Achievement award of American Nuclear Society.

He is the editor-in-chief of the Nuclear Engineering and Design Journal. He has served as adjunct professor at several international universities. He has authored more than 100 publications in technical journals.

# Comments from floor

**Prof. Mamoru Ozawa**
Faculty of Safety Science Department of Safety Management, Kansai University

## The first important point to be noted

Even a complex simulations codes reflect only a limited number of aspects of the real systems. This is mainly because these simulation codes are constructed on the basis of various approximations and/or assumptions.

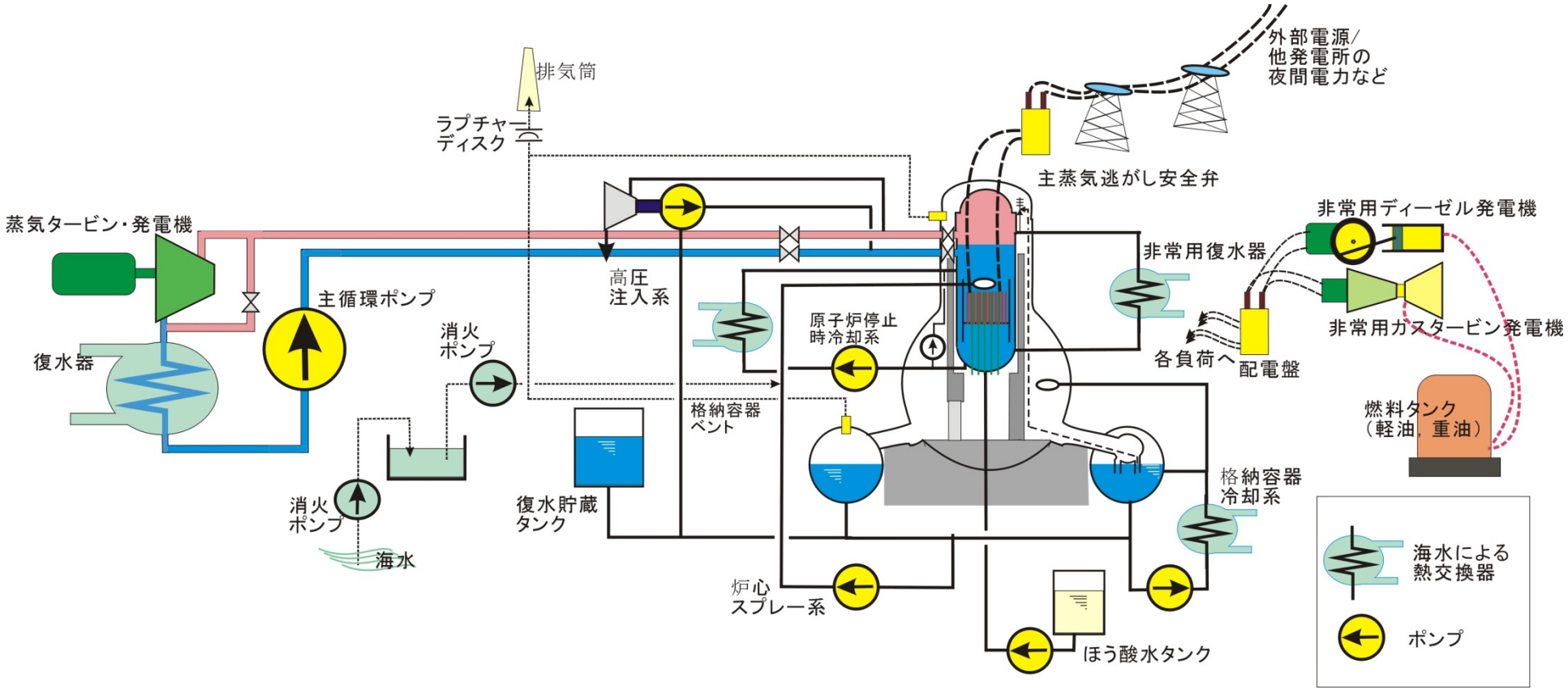
The real system we designed is much more complex than we expect. Thus the safety of the real system is not realized on a computer.

We must understand that whole real system is consisted of mechanical elements, human activity and/or factors as well as social and economical factors.

Thermal engineering contributes only a limited area. Severe accident may be started from even a simple trivial event. In accordance with the time evolution of the event, various factors exert influence. In some case these additional factors may be led to a severe event.

# The second point

An importance of education for excellent leaders and their staff, not only based on the simulator training but also based on the practical exercise using practical systems.




**Training system of 200 – 300MWt reactor model**
**Reactor is simulated with electric heaters**

# Mental Resilience

Masahiro Kawaji

City College of New York/University of Toronto

- Fukushima Daiichi NPP during and after the tsunami was like a “war zone”
  - Difficult decision making with inadequate reactor information, confusing chain of command, many unexpected problems, etc.
  - Never gave up and prevented worse consequences
- Many reactor operators in US nuclear power plants served in US navy and manned nuclear submarines
  - They must be well trained to deal with numerous unforeseen events in a war
  - A submarine commander must make decisions under difficult conditions
- Good to have civilian NPP managers and senior staff acquire mental toughness and resilience required of nuclear submarine personnel

# Summary of "The Role of Thermal Science for Nuclear Disaster Resilience"

- Recognize the Importance of Resilience Engineering (Safety-II)
  - ✓ Knowing what to do, or being able to respond to regular and irregular changes and disturbances.
  - ✓ Knowing what to look for, or being able to monitor that which changes, or may change.
  - ✓ Knowing what to expect, or being able to anticipate changes, threats and opportunities further into the future.
  - ✓ Knowing what has happened, or being able to learn from experiences to obtain lessons.
- Additional Resources/ Success-based Learning/ Proactive Intervention/ Self-monitoring
- Paradigm Sift from Failure Search to Path Set Search
- Flexible and Dynamic Technical Solutions must be needed:

  Ultimate Heat Sink, Enough Electricity, Enough Confinement Capability
- To Develop Tools for Faster-than-real-time Simulation including Human Intervention

  - Prior to Accident Management

  - During Accident Management
- Human Resource Development (from the viewpoint of "Anticipating")

  On-site: **Strong Leader & Well-trained Operators**
  Importance of Training by using Practical Scale Simulator

  At Headquarter: **Generalist** who must have Multi-interest/ Interdisciplinary/ Overlook.
  Need to Learn more about Liberal Arts Besides Various Academic Fields